MULTIMEDIA UNIVERSITY

STUDENT ID NO

MULTIMEDIA UNIVERSITY

FINAL EXAMINATION

TRIMESTER 1, 2022/2023 (TERM ID 2210)

EEL2186–CIRCUITS AND SIGNALS

(LE / EE / CE / NE / TE)

13 FEBRUARY 2023
9.00 A.M – 11.00 A.M.
(2 Hours)

INSTRUCTIONS TO STUDENT

1. This question paper consists of 8 pages including cover page and appendices, with 5 questions only.

2. Attempt **ALL FIVE** questions. The distribution of the marks for each question is given.

3. Please write all your answers in the answer booklet provided.

Question 1

A network is given with its corresponding graph as shown in Figure Q1.

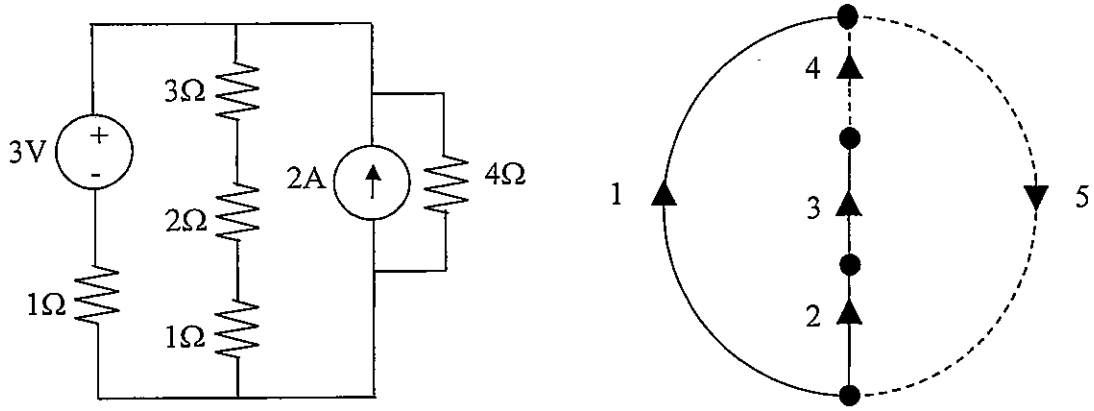

Figure Q1

(i) Obtain the voltage source matrix E, current source matrix I, branch impedance matrix Z and fundamental loop matrix D. [6 marks]

(ii) Compute Z_L^{-1}, where $Z_L = DZD^T$. [5 marks]

(iii) Use loop analysis to solve for the chord currents i_c. (You need not solve for the branch currents and voltages.) [5 marks]

Question 2

(a) Given a continuous-time signal $f(t) = Atu(t)$, where A is a positive constant, determine whether $f(t)$ is an energy signal, a power signal or neither. [5 marks]

(b) (i) Sketch $x[n] = 4\delta[n] + u[n] - u[n-3]$ for $0 \le n \le 3$. [3 marks]

(ii) Using $h[n] = [\ldots\ 0\ \underline{1}\ 4\ 0\ \ldots]$ and the sequence $x[n]$ obtained in part (b)(i), compute $y[n]$ for $0 \le n \le 3$, where $y[n] = h[n] * x[n]$. Show the convolution steps by using either a mathematical, table or graphical evaluation method. [6 marks]

(iii) Express the output sequence $y[n]$ obtained in part (b)(ii) in terms of the unit step function. [3 marks]

Continued...

Question 3

Consider the circuit shown in Figure Q3.

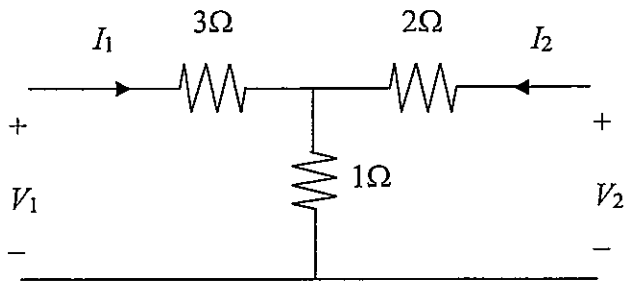

Figure Q3

(i) Derive the *g*-parameters directly without converting from any other types of parameters. You are given that,

$$I_1 = g_{11}V_1 + g_{12}I_2$$
$$V_2 = g_{21}V_1 + g_{22}I_2$$ [12 marks]

(ii) Convert the *g*-parameters obtained in part (i) to *a*-parameters. [5 marks]

Continued...

Question 4

(a) Determine the impulse response of the following transfer function:

$$H(s) = \frac{7}{s(s+3)}$$ [5 marks]

(b) Consider the electrical network shown in Figure Q4(b). The switch has been closed for a long time before it is opened at $t = 0$.

(i) Draw the s-domain circuit showing all parameters including the initial conditions of the storage elements. [7 marks]

(ii) Based on the s-domain circuit in part (b)(i), determine the expression for $I(s)$. [5 marks]

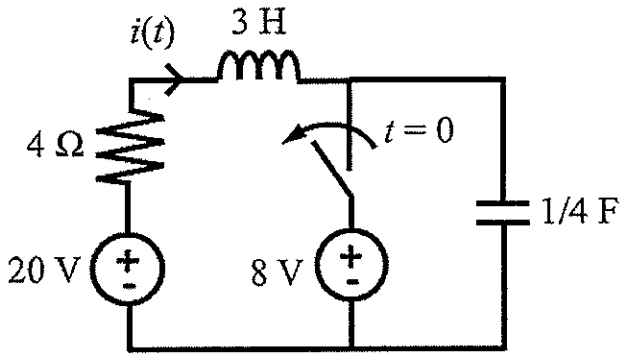

Figure Q4(b)

(c) For the circuit shown in Figure Q4(c), obtain the state equation in the standard matrix format. [8 marks]

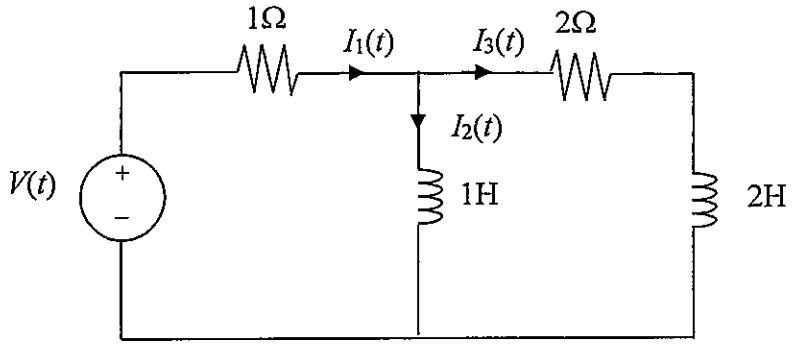

Figure Q4(c)

Continued...

Question 5

(a) Synthesize the following impedance function as an inductor-capacitor (LC) network using Cauer first form. Draw the synthesized network. [10 marks]

$$Z(s) = \frac{3s(s^2+16)}{(s^2+9)}$$

(b) Consider a network with the following impedance function. Check whether $Z(s)$ belongs to an RC or RL network. Justify your answer. [6 marks]

$$Z(s) = \frac{2s^2+8s+6}{s^2+7s+10}$$

(c) Consider the following low-pass filter specifications:

Permissible passband attenuation = 2dB;
Passband edge frequency = 2kHz;
Minimum stopband attenuation = 40dB;
Stopband edge frequency = 7kHz.

(i) It is desired to synthesize a filter which has a maximally flat magnitude response. What type of filter should be used? [1 mark]

(ii) For the filter type chosen in part (c)(i), find the minimum filter order required to meet the given specifications. [8 marks]

Continued...

Appendix A: Table of Laplace Transform Pairs

No.	*t*-domain function	*s*-domain transform
1.	$\delta(t)$	1
2.	$u(t)$	$1/s$
3.	$tu(t)$	$1/s^2$
4.	t^n	$\frac{n!}{s^{n+1}}$
5.	e^{-kt}	$\frac{1}{s+k}$
6.	$t^n e^{-kt}$	$\frac{n!}{(s+k)^{n+1}}$
7.	$\sin\omega t$	$\frac{\omega}{s^2+\omega^2}$
8.	$\cos\omega t$	$\frac{s}{s^2+\omega^2}$
9.	$e^{-kt}\sin\omega t$	$\frac{\omega}{(s+k)^2+\omega^2}$
10.	$e^{-kt}\cos\omega t$	$\frac{s+k}{(s+k)^2+\omega^2}$
11.	$t\sin\omega t$	$\frac{2\omega s}{(s^2+\omega^2)^2}$
12.	$\sinh\beta t$	$\frac{\beta}{s^2-\beta^2}$
13.	$\cosh\beta t$	$\frac{s}{s^2-\beta^2}$
14.	$\sin(\omega t+\phi)$	$\frac{s\sin\phi+\omega\cos\phi}{s^2+\omega^2}$
15.	$2\lvert k\rvert e^{-\sigma t}\cos(\omega t-\varphi)$, where $k=\lvert k\rvert\angle\varphi$	$\frac{k}{s+\sigma+j\omega}+\frac{k^*}{s+\sigma-j\omega}$
16.	$f(t)$ periodic with period T	$\frac{1}{1-e^{-Ts}}\int_0^T f(t)e^{-st}dt$

Continued...

Appendix B: Table of Laplace Transform Properties

Operations	$f(t)$	$F(s)$
1. Multiplication by scalar	$kf(t)$	$kF(s)$
2. Scaling	$f(kt),\ k \geq 0$	$\frac{1}{k}F\left(\frac{s}{k}\right)$
3. Addition and subtraction	$f_1(t) \pm f_2(t)$	$F_1(s) \pm F_2(s)$
4. Time shift	$f(t-t_o)u(t-t_o)$	$F(s)e^{-st_o}$
5. Frequency shift	$f(t)e^{\alpha t}$	$F(s-\alpha)$
6. Time differentiation	$\frac{df(t)}{dt}$	$sF(s) - f(0)$
	$\frac{d^2f(t)}{dt^2}$	$s^2F(s) - sf(0) - f'(0)$
7. Time integration	$\int_0^t f(\tau)d\tau$	$\frac{1}{s}F(s)$
8. Initial value	$\lim_{t\to 0} f(t)$	$\lim_{s\to\infty} sF(s)$
9. Final value	$\lim_{t\to\infty} f(t)$	$\lim_{s\to 0} sF(s)$
10. Frequency differentiation	$tf(t)$	$-\frac{dF(s)}{ds}$
11. Frequency integration	$\frac{f(t)}{t}$	$\int_s^\infty F(\tilde{s})d\tilde{s}$
12. Convolution	$f_1(t) * f_2(t)$	$F_1(s)F_2(s)$

Continued...

Appendix C: Two-port network conversion table between *z*-, *y*-, *h*-, *g*-, *a*- and *b*-parameters.

	z	*y*	*h*	*g*	*a*	*b*
z	$\begin{matrix} z_{11} & z_{12} \\ z_{21} & z_{22} \end{matrix}$	$\begin{matrix} \frac{y_{22}}{\Delta y} & -\frac{y_{12}}{\Delta y} \\ -\frac{y_{21}}{\Delta y} & \frac{y_{11}}{\Delta y} \end{matrix}$	$\begin{matrix} \frac{\Delta h}{h_{22}} & \frac{h_{12}}{h_{22}} \\ -\frac{h_{21}}{h_{22}} & \frac{1}{h_{22}} \end{matrix}$	$\begin{matrix} \frac{1}{g_{11}} & -\frac{g_{12}}{g_{11}} \\ \frac{g_{21}}{g_{11}} & \frac{\Delta g}{g_{11}} \end{matrix}$	$\begin{matrix} \frac{A}{C} & \frac{\Delta a}{C} \\ \frac{1}{C} & \frac{D}{C} \end{matrix}$	$\begin{matrix} \frac{d}{c} & \frac{1}{c} \\ \frac{\Delta b}{c} & \frac{a}{c} \end{matrix}$
y	$\begin{matrix} \frac{z_{22}}{\Delta z} & -\frac{z_{12}}{\Delta z} \\ -\frac{z_{21}}{\Delta z} & \frac{z_{11}}{\Delta z} \end{matrix}$	$\begin{matrix} y_{11} & y_{12} \\ y_{21} & y_{22} \end{matrix}$	$\begin{matrix} \frac{1}{h_{11}} & -\frac{h_{12}}{h_{11}} \\ \frac{h_{21}}{h_{11}} & \frac{\Delta h}{h_{11}} \end{matrix}$	$\begin{matrix} \frac{\Delta g}{g_{22}} & \frac{g_{12}}{g_{22}} \\ -\frac{g_{21}}{g_{22}} & \frac{1}{g_{22}} \end{matrix}$	$\begin{matrix} \frac{D}{B} & -\frac{\Delta a}{B} \\ -\frac{1}{B} & \frac{A}{B} \end{matrix}$	$\begin{matrix} \frac{a}{b} & -\frac{1}{b} \\ -\frac{\Delta b}{b} & \frac{d}{b} \end{matrix}$
h	$\begin{matrix} \frac{\Delta z}{z_{22}} & \frac{z_{12}}{z_{22}} \\ -\frac{z_{21}}{z_{22}} & \frac{1}{z_{22}} \end{matrix}$	$\begin{matrix} \frac{1}{y_{11}} & -\frac{y_{12}}{y_{11}} \\ \frac{y_{21}}{y_{11}} & \frac{\Delta y}{y_{11}} \end{matrix}$	$\begin{matrix} h_{11} & h_{12} \\ h_{21} & h_{22} \end{matrix}$	$\begin{matrix} \frac{g_{22}}{\Delta g} & -\frac{g_{12}}{\Delta g} \\ -\frac{g_{21}}{\Delta g} & \frac{g_{11}}{\Delta g} \end{matrix}$	$\begin{matrix} \frac{B}{D} & \frac{\Delta a}{D} \\ -\frac{1}{D} & \frac{C}{D} \end{matrix}$	$\begin{matrix} \frac{b}{a} & \frac{1}{a} \\ -\frac{\Delta b}{a} & \frac{c}{a} \end{matrix}$
g	$\begin{matrix} \frac{1}{z_{11}} & -\frac{z_{12}}{z_{11}} \\ \frac{z_{21}}{z_{11}} & \frac{\Delta z}{z_{11}} \end{matrix}$	$\begin{matrix} \frac{\Delta y}{y_{22}} & \frac{y_{12}}{y_{22}} \\ -\frac{y_{21}}{y_{22}} & \frac{1}{y_{22}} \end{matrix}$	$\begin{matrix} \frac{h_{22}}{\Delta h} & -\frac{h_{12}}{\Delta h} \\ -\frac{h_{21}}{\Delta h} & \frac{h_{11}}{\Delta h} \end{matrix}$	$\begin{matrix} g_{11} & g_{12} \\ g_{21} & g_{22} \end{matrix}$	$\begin{matrix} \frac{C}{A} & -\frac{\Delta a}{A} \\ \frac{1}{A} & \frac{B}{A} \end{matrix}$	$\begin{matrix} \frac{c}{d} & -\frac{1}{d} \\ \frac{\Delta b}{d} & \frac{b}{d} \end{matrix}$
a	$\begin{matrix} \frac{z_{11}}{z_{21}} & \frac{\Delta z}{z_{21}} \\ \frac{1}{z_{21}} & \frac{z_{22}}{z_{21}} \end{matrix}$	$\begin{matrix} -\frac{y_{22}}{y_{21}} & -\frac{1}{y_{21}} \\ -\frac{\Delta y}{y_{21}} & -\frac{y_{11}}{y_{21}} \end{matrix}$	$\begin{matrix} -\frac{\Delta h}{h_{21}} & -\frac{h_{11}}{h_{21}} \\ -\frac{h_{22}}{h_{21}} & -\frac{1}{h_{21}} \end{matrix}$	$\begin{matrix} \frac{1}{g_{21}} & \frac{g_{22}}{g_{21}} \\ \frac{g_{11}}{g_{21}} & \frac{\Delta g}{g_{21}} \end{matrix}$	$\begin{matrix} A & B \\ C & D \end{matrix}$	$\begin{matrix} \frac{d}{\Delta b} & \frac{b}{\Delta b} \\ \frac{c}{\Delta b} & \frac{a}{\Delta b} \end{matrix}$
b	$\begin{matrix} \frac{z_{22}}{z_{12}} & \frac{\Delta z}{z_{12}} \\ \frac{1}{z_{12}} & \frac{z_{11}}{z_{12}} \end{matrix}$	$\begin{matrix} -\frac{y_{11}}{y_{12}} & -\frac{1}{y_{12}} \\ -\frac{\Delta y}{y_{12}} & -\frac{y_{22}}{y_{12}} \end{matrix}$	$\begin{matrix} \frac{1}{h_{12}} & \frac{h_{11}}{h_{12}} \\ \frac{h_{22}}{h_{12}} & \frac{\Delta h}{h_{12}} \end{matrix}$	$\begin{matrix} -\frac{\Delta g}{g_{12}} & -\frac{g_{22}}{g_{12}} \\ -\frac{g_{11}}{g_{12}} & -\frac{1}{g_{12}} \end{matrix}$	$\begin{matrix} \frac{D}{\Delta a} & \frac{B}{\Delta a} \\ \frac{C}{\Delta a} & \frac{A}{\Delta a} \end{matrix}$	$\begin{matrix} a & b \\ c & d \end{matrix}$

$\Delta z = z_{11}z_{22} - z_{12}z_{21}$; $\Delta y = y_{11}y_{22} - y_{12}y_{21}$

$\Delta h = h_{11}h_{22} - h_{12}h_{21}$; $\Delta g = g_{11}g_{22} - g_{12}g_{21}$

$\Delta a = AD - BC$; $\Delta b = ad - bc$

End of Paper